PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 29 May 2001 (29.05.01)	
International application No. PCT/DK00/00464	**Applicant's or agent's file reference** P 00 054 WO
International filing date (day/month/year) 21 August 2000 (21.08.00)	**Priority date** (day/month/year) 20 August 1999 (20.08.99)
Applicant RISO, Ronald, R.	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

13 March 2001 (13.03.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer J. Leitao
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

12

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P 00 054 WO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/DK00/00464	21.08.2000	20.08.1999
International Patent Classification (IPC) or national classification and IPC7		
A 61 F 2/72		
Applicant		
RISO, Ronald R.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
13.03.2001	06.12.2001
Name and mailing address of the IPEA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88 Telex 17978 PATOREG-S	Cilla Lyckman/AE Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/DK00/00464

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed

☒ the description:
pages 1-16 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☒ the claims:
pages _____ , as originally filed
pages _____ , as amended (together with any statement) under article 19
pages _____ , filed with the demand
pages 17-20 , filed with the letter of 03.12.2001

☒ the drawings:
pages 1-3 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☐ the sequence listing part of the description:
pages _____ , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/DK00/00464

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application,

☒ claims Nos. 6,13,19,26

because:

☐ the said international application, or the said claims Nos. _____
relate to the following subject matter which does not require an international preliminary examination *(specify)*:

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. _____
are so unclear that no meaningful opinion could be formed *(specify)*:

☐ the claims, or said claims Nos. _____ are so inadequately supported
by the description that no meaningful opinion could be formed.

☒ no international search report has been established for said claims Nos. 6,13,19,26 .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/DK00/00464

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-5,7-12,14-18,20-25	YES
	Claims		NO
Inventive step (IS)	Claims	4,9-12,17,22-25	YES
	Claims	1-3,5,7-8,14-16,18,20-21	NO
Industrial applicability (IA)	Claims	1-5,7-12,14-18,20-25	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

In the International search report the following two documents are cited:

D1: MUNOZ R et al: "Implantable electrode for chronic recording from skeletal muscle"
D2: EP 0421780 A

In document D1, a method for control of a prosthesis using EMG signals to generate control signals is described (see abstract and introduction). The EMG signals are received by an electrode dedicated to a source of EMG signals. The electrode is implanted in a muscle.

The invention according to claims 1-3, 5, 14-16 and 18 differs from what is described in document D1 in that one or more sets of electrodes are used instead of one. It is though obvious for a person skilled in the art to use one or more sets of electrodes for receiving the EMG signals in the method described in D1, especially since it is known in the art to use a plurality of electrodes for controlling a prosthesis (see for example D2). Hence what is claimed in claims 1-3, 5, 14-16 and 18 is not considered to involve an inventive step.

The invention according to claims 7-8 and 20-21 differs from what is described in document D1 in that the EMG signals are processed by signal processing means, utilising an artificial network, whereby control signals for the artificial limb are produced. This difference solves the problem of analysing the measured signals. In document D2, a myoelectric control system is described. The measured EMG signals are processed by signal processing means, utilising a neural network, solving the problem of analysing the measured signals. It is obvious for a person skilled in the art to learn from the teaching in D2 to

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Box V

adapt the control of the prosthesis described in D1. What is claimed in claims 7-8 and 20-21 is not considered to involve an inventive step.

According to the arguments stated above, the invention according to claims 1-3, 5, 7-8, 14-16, 18 and 20-21 is novel but is not considered to involve an inventive step. According to the arguments stated above, the invention according to claims 4, 9-12, 17 and 20-21 is novel and is considered to involve an inventive step. The invention according to claims 1-5, 7-12, 14-18 and 20-25 is considered to be industrially applicable.

Amended Patent Claims

1. A method of controlling a prosthesis such as an artificial limb, whereby electromyographic (EMG) signals are used to generate control signals for one or more prostheses such as artificial limbs and whereby the electromyographic (EMG) signals are received by at least one set of of electrodes dedicated to a source of electromyographic (EMG) signals.

2. Method according to claim 1, c h a r a c t e r i z e d i n t h a t said at least one set of dedicated electrodes is placed subcutaneously.

3. Method according to claim 1, c h a r a c t e r i z e d i n t h a t said at least one set of dedicated electrodes is placed epimesially.

4. Method according to claim 1, c h a r a c t e r i z e d i n t h a t said at least one set of dedicated electrodes is placed intramuscularly.

5. Method according to one or more of claims 1 - 4, c h a r a c t e r i z e d i n t h a t said at least one set of dedicated electrodes is implanted in a muscle or muscles.

6. Method according to one or more of claims 1 - 5, c h a r a c t e r i z e d i n t h a t the electromyographic (EMG) signals from said at least one set of dedicated electrodes is transmitted to signal processing means by wireless transmission.

7. Method according to one or more of claims 1 - 6, c h a r a c t e r i z e d i n t h a t the electromyographic (EMG) signals from said at least one set of dedicated electrodes is processed by signal processing means, whereby control signals for the artificial limb(s) are produced, said signal processing means utilizing a pattern recognition method.

8. Method according to one or more of claims 1 - 7, characterized in that the control signals of the artificial limb(s) are generated by utilizing an artificial neural network (ANN).

9. Method according to one or more of claims 1 - 8, characterized in that the electromyographic (EMG) signals are received by four or more sets of dedicated electrodes placed in relation to at least four muscles or distinct functional muscle compartments.

10. Method according to claim 9, characterized in that the method is utilized to control an artificial arm and/or hand and in that at least one set of electrodes is placed in relation to at least each of the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus and Extensor Pollicis Longus.

11. Method according to claim 9, characterized in that the method is utilized to control an artificial arm and/or hand and in that at least one electrode is placed in relation to at least each of the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus, Extensor Pollicis Longus, Pronator Teres, Supinator, Flexor Carpi Radialis and Extensor Carpi Radialis.

12. Method according to one or more of claims 1 - 11, characterized in that two or more sets of dedicated electrodes are placed in relation to at least one muscle, said two or more dedicated electrodes being placed in relation to different parts of said at least one muscle.

13. Method according to one or more of claims 1 - 12, characterized in that electroneurographic (ENG) signals are received by one or more separate sets of ENG-electrodes and that these ENG-signals are used as complimentary signals for generating control signals.

14. A system for controlling a prosthesis, such as an artificial limb, wherein electromyographic (EMG) signals are used to generate control signals for at least one artifi-

cial limb and wherein the system comprises at least one set of electrodes, each dedicated to a source of electromyographic (EMG) signals for receipt of the electromyographic (EMG) signals.

15. System according to claim 14, characterized in that said at least one set of dedicated electrodes is configured for subcutaneous placing.

16. System according to claim 14, characterized in that said at least one set of dedicated electrodes is configured for epimesial placing.

17. System according to claim 14, characterized in that said at least one set of dedicated electrodes is configured for intramuscular placing.

18. System according to one or more of claims 14 - 17, characterized in that said at least one set of dedicated electrodes is configured for implantation in a muscle or muscles.

19. System according to one or more of claims 14 - 18, characterized in that the system comprises means for transmitting the electromyographic (EMG) signals from said at least one set of dedicated electrodes to signal processing means by wireless transmission.

20. System according to one or more of claims 14 - 19, characterized in that the system comprises signal processing means for producing control signals for the artificial limb(s), said signal processing means utilizing a pattern recognition method.

21. System according to one or more of claims 14 - 20, characterized in that the system comprises an artificial neural network (ANN) for generating control signals for the artificial limb(s).

22. System according to one or more of claims 14 - 21, characterized in that the system comprises four or more sets of dedicated electrodes placed in relation to at least four muscles or functional distinct muscle compartments for receipt of electromyographic (EMG) signals.

23. System according to claim 22, characterized in that the system is utilized to control an artificial arm and/or hand wherein at least one set of electrodes is placed in relation to each of the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus and Extensor Pollicis Longus.

24. System according to claim 22, characterized in that the system is utilized to control an artificial arm and/or hand and in that at least one set of electrodes is placed in relation to each of the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus, Extensor Pollicis Longus, Pronator Teres, Supinator, Flexor Carpi Radialis and Extensor Carpi Radialis.

25. System according to one or more of claims 14 - 24, characterized in that the system comprises two or more sets of dedicated electrodes placed in relation to at least one muscle, and in that said two or more sets of dedicated electrodes are placed in relation to different parts of said at least one muscle.

26. Method according to one or more of claims 14 - 25, characterized in that the system comprises at least one set of electroneurographic (ENG) electrodes for receiving electroneurographic (ENG) signals and in that these ENG-signals are used as complimentary signals for generating control signals.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
P 00 054 WO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/DK 00/ 00464	21/08/2000	20/08/1999
Applicant		
RISO, Ronald, R.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [X] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 4

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

ational application No.
PCT/DK 00/00464

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-3,5-10,12-14,16-21

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-3,5-10,12-14,16-21

   The method according to claim 2-3 and 7-10 and corresponding system in claims 13,14 and 18-21 including the additional feature of the placement of the electrodes

2. Claims: 4,15

   The method and the system accrding to claims 4 and 15 including the additional feature that the EMG signals from the electrodes are transmitted to signal processing means by wireless transmission

3. Claims: 5,6,16,17

   The method according to claims 5 and 6 and the corresponding system in claims 16 and 17 including the additional feature that a pattern recognition method is used to produce the control signals for the prosthesis

4. Claims: 11,22

   The method and the system according to claims 11 and 22 including the additional feature that electroneurographic signals are used as complimentary signals for generating control signals

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DK 00/00464

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61F2/72

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MUNOZ R ET AL: "Implantable electrode for chronic recording from skeletal muscle" PROCEEDINGS - 19TH INTERNATIONAL CONFERENCE - IEEE/EMBS, 30 October 1997 (1997-10-30) - 2 November 1997 (1997-11-02), pages 2445-2447, XP002901486 CHICAGO, IL. US page 2445, column 1 ---	1-3, 7-10, 12-14, 18-21
X	EP 0 421 780 A (STEEPER HUGH LTD) 10 April 1991 (1991-04-10) column 1, line 1 -column 2, line 50 -----	1,5-12, 16-21

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 December 2000	21. 05. 2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Cilla Lyckman

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/DK 00/00464

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0421780 A	10-04-1991	DE 69029553 D	13-02-1997
		DE 69029553 T	12-06-1997

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 March 2001 (01.03.2001)

PCT

(10) International Publication Number
WO 01/13778 A2

(51) International Patent Classification[7]: A61B

(21) International Application Number: PCT/DK00/00464

(22) International Filing Date: 21 August 2000 (21.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PA 1999 01149 20 August 1999 (20.08.1999) DK

(71) Applicant and
(72) Inventor: **RISO, Ronald, R.** [US/DK]; Herluf Trolles Gade 28, 2.th., DK-9000 Aalborg (DK).

(74) Agent: **PATENTGRUPPEN APS**; Arosgården, Aaboulevarden 23, DK-8000 Aarhus C (DK).

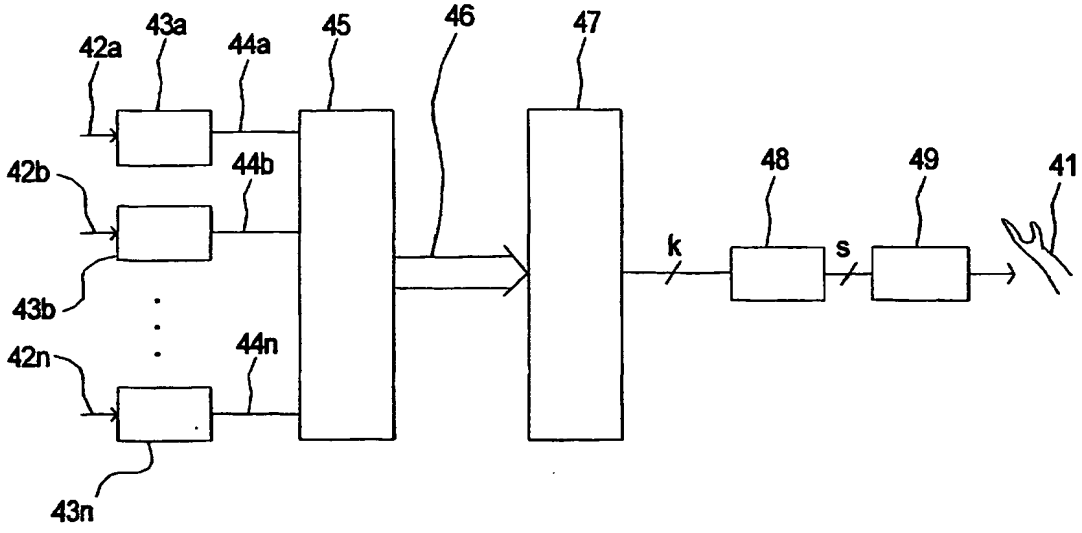
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *Without international search report and to be republished upon receipt of that report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: EMG CONTROL OF PROSTHESIS



(57) Abstract: A method and a system for controlling a prosthesis such as an artificial limb. Electromyographic (EMG) signals are used to generate control signals for one or more prostheses such as artificial limbs. The electromyographic (EMG) signals are received by one or more sets of electrodes dedicated to a source of electromyographic (EMG) signals. By using dedicated electrodes, electromyographic (EMG) signals originating from well-defined sources may be picked up. Consequently, EMG signals stemming from a muscle which would be activated by a human being when this human being would move a part of his body, e.g. a limb or a part of a limb replaced by a prosthesis, may be detected, picked up and used to control the corresponding prosthesis or corresponding part of the prosthesis.

WO 01/13778 A2

EMG CONTROL OF PROSTHESIS

Field of the invention

The invention relates to a method and a system for controlling prostheses such as artificial limbs according to claim 1 and claim 12, respectively.

Background of the invention

The use of prostheses such as artificial limbs, e.g. hands, arms, legs, feet etc. for human beings who have lost a limb, is well-known.

Further, it is known that such artificial limbs may be constructed to provide (limited) movement of the limb in relation to the user or to provide movement between two parts of the limb, for example the turning of an artificial hand in relation to a corresponding artificial arm. These movements, which may be performed with only one or two degrees of freedom, may be body-powered, be powered electrically or controlled by special control arrangements which can be activated by the user, i.e. the wearer of the prosthesis.

Great efforts have been made to develop a user-friendly way of controlling the movement of artificial limbs. Thus, the use of electromyographic signals, also referred to as EMG signals in the following, have been utilized in prior-art to control prostheses or artificial limbs. In prior-art, these signals stemming from muscles which are activated, e.g. contracted or extended, have been picked up by contact electrodes, placed on the skin of a human being in places where residual muscles are present, e.g. in proximity of residual muscles. As one or more of these residual muscles is/are activated by the human being, EMG signals are generated. These electrical signals are picked up by contact electrodes and can be used as input to a control circuit for initiating movement of an artificial limb.

However, the contact electrodes will usually be placed for example on opposing sides of a lower arm or in such a manner that each electrode will pick up EMG signals from more than one muscle, i.e. a group of muscles. However, the signals picked up by these contact electrodes will still be able to provide a sufficient basis for controlling movements with one degree of freedom, for example the opening and closing of a hand in a palmer grasp mode, as the group of muscles on one side of the lower arm will provide a detectable signal of movement in one direction, for example closing of the hand, while the group of muscles on the other side of the lower arm will provide a detectable signal of movement in the other direction, for example opening of the hand. The user of such a prosthesis thus has to learn that once a certain group of muscles is activated, a palmer grip will be performed, and that the palmer grip will be relaxed and the hand will open when a certain other group of muscles is activated.

This has the disadvantage that some sort of training is required before the use of the prosthesis may be mastered by the user. Further, the movements that may be performed by the prosthesis are limited to relatively simple movements, e.g. opening and closing of a hand. However, it will also be possible to configure a prosthesis capable of performing more than one simple movement by having a switch-over function, for example a switch, which may be activated by the user, whereby the prosthesis may perform another movement, for example a pinch grip or a rotation of a wrist. This second movement will also be triggered by EMG signals from the same muscle groups as the first movement, and the activation by the user will thus be complicated and awkward, and the two different movements cannot be performed simultaneously.

The use of more than two sets of contact electrodes, i.e. electrodes applied to the skin of the user, for receiving EMG signals from different muscles or muscle groups will be difficult if not impossible in practice, as two contact electrodes placed for example on the same side of a lower arm will inevitably receive the same EMG signals emitted by the same muscles or muscle groups (cross talk). Consequently, it will be difficult to make a distinction between the signals received from these two contact electrodes and thus make control of two different movements by these signals impossible. Even if it were possible to place two contact electrodes on the same side of an arm in such a manner that the signals picked up by these contact electrodes

arm in such a manner that the signals picked up by these contact electrodes would be distinctly different, i.e. not involving substantial cross talk, it would be necessary to teach the user to activate more than two muscles or muscle groups independently of each other in order to be able to achieve motions of the artificial limb with more than one degree of freedom. Hence, this would involve even more extensive training before the user would be able to master the use of the prosthesis satisfactorily.

Thus, it is an object of the present invention to provide a method and a system for controlling a prosthesis such as an artificial limb, whereby the movement of the prosthesis and/or parts thereof may be performed in a user-friendly manner by the user.

Another object of the invention is to provide a method and a system for controlling a prosthesis such as an artificial limb, whereby the movements of the prosthesis and/or part/parts thereof may be performed in a highly intuitive manner, e.g. a manner, which will be natural to the user.

It is a further object of the invention to provide a method and a system whereby relatively complex movements may be performed by the prosthesis and/or parts thereof.

These and other objects are achieved by the invention.

Summary of the invention

As stated in claim 1, the invention relates to a method of controlling a prosthesis such as an artificial limb, whereby electromyographic (EMG) signals are used to generate control signals for one or more prostheses such as artificial limbs, and whereby the electromyographic (EMG) signals are received by one or more sets of electrodes dedicated to a source of electromyographic (EMG) signals.

By using dedicated electrodes, i.e. electrodes designed and placed in such manner that the signals picked up by each of these sets of electrodes emanate from a predefined source, e.g. a certain muscle or a certain compartment within the muscle, elec-

tromyographic (EMG) signals originating from well-defined sources may be picked up.

Consequently, EMG signals stemming from a muscle which would be activated by a human being when this human being should desire to move a part of his body, e.g. a limb or a part of a limb replaced by a prosthesis, may be detected, picked up and used to control the corresponding prosthesis or corresponding part of the prosthesis.

Thus, the prosthesis or part of the prosthesis may be moved by the user in a highly intuitive way.

Further, it will be possible to perform relatively complex movements of a prosthesis or part/parts thereof as EMG signals may be received from muscles which would normally have been activated by the user of the prosthesis when performing the natural movements of the missing body part(s). These signals may thus be used to control the corresponding prosthesis parts, whereby the user may perform the desired movements intuitively, i.e. without having to learn to move a particular muscle group(s) in a particular way and/or without having to activate switch-over mechanisms etc.

A further advantage of the invention is related to environmental control, as the EMG control method may be applied for controlling light, appliances etc, which the user desires to control, e.g. turn on and off. Such an environmental control function may be configured in relation to the EMG control method for controlling a prosthesis, whereby the user would be able to control such appliances, for example via wireless control, without actually having to manipulate a control means, e.g. a switch.

The electrodes are constituted by sets of electrodes. In order to pick up an electrical signal, e.g. an electrical potential, a measurement or detection has to be made in at least two (spatially) different places in order to achieve a potential difference. Thus, at least two electrodes constitute a set of electrodes. Evidently, such a set of electrodes may be configured as a unit, whereby the distance between the two measuring

or detection points of the set of electrodes is predefined and kept at a constant by the unit, or the electrodes may be separate parts.

The one or more sets of dedicated electrodes may preferably, as stated in claim 2, be placed subcutaneously, epimesially or intramuscularly, whereby it is ensured that relatively strong EMG signals from the corresponding muscle will be received by the electrode and that these signals will not be influenced by signals stemming from other sources, e.g. other muscles (cross talk).

Further, said one or more sets of dedicated electrodes may be implanted in a muscle or muscles, as stated in claim 3, whereby the EMG signals will be received by the electrodes in a relatively powerful form without any cross talk from other sources of EMG signals.

The muscles, in which the sets of electrodes are implanted, may for example be residual muscles related to a missing part of the body replaced by a prosthesis, e.g. muscles in an arm of a below elbow (BE) amputee. However, the sets of electrodes may be implanted in any residual limb or other muscles as desired in order to improve the EMG signal pattern discriminality. For example, a muscle in a shoulder part of an amputee may provide resourceful EMG signal information relating to the desired movements of for example a hand or an arm.

Preferably, as stated in claim 4, the electromyographic (EMG) signals from said one or more sets of dedicated electrodes may be transmitted to signal processing means by wireless transmission, whereby the disadvantages and/or discomfort associated with signal wires protruding through the skin of the user may be avoided.

In a preferred embodiment, as stated in claim 5, the electromyographic (EMG) signals from said one or more sets of dedicated electrodes are processed by signal processing means, whereby control signals for the artificial limb(s) are produced, said signal processing means utilizing a pattern recognition method. Hereby, the control signals may be produced in an advantageous manner and the control signals may

consistently lead to the desired movements of the prosthesis and/or part/parts thereof irrespective of the fact that the EMG signals may vary in form and/or amplitude.

As stated in claim 6, the control signals of the artificial limb(s) may be generated by utilizing an artificial neural network (ANN), whereby the pattern recognition method may be performed in a particularly advantageous manner.

As stated in claim 7, the electromyographic (EMG) signals may preferably be received by four or more sets of dedicated electrodes, located in relation to at least four muscles, or combinations of distinct functional muscle compartments, whereby a sufficient number of distinct EMG signals may be provided in order to achieve at least four different movements of a limb or part/parts thereof.

As stated in claim 8, the method may be utilized to control an artificial arm and/or hand, whereby one or more sets of electrodes is/are placed in relation to at least the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus and Extensor Pollicis Longus. This may provide at least four different movements of the artificial arm or part/parts thereof, for example closing and opening of a hand in a palmer grasp mode and closing and opening of a hand in a lateral grasp (also referred to as a key grip) mode.

As stated in claim 9, the method may be utilized to control an artificial arm and/or hand, whereby one or more sets of electrodes are placed in relation to at least the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus, Extensor Pollicis Longus, Pronator Teres, Supinator, Flexor Carpi Radialis and Extensor Carpi Radialis. Hereby, an artificial arm with an even larger degree of freedom may be controlled in a user-friendly and highly intuitive manner by the user. An artificial arm may for example be configured for opening/closing the hand and performing a palmer or a key grip, rotating or flexing the wrist, extending or bending the fingers and the thumb (selectively) etc., making all these functions controllable by the amputee (the user) in a natural and highly intuitive manner.

As stated in claim 10, two or more dedicated sets of electrodes may be placed in relation to at least one muscle, said two or more sets of dedicated electrodes being placed in relation to different parts of said at least one muscle. Hereby, EMG signals from different parts of the muscle may be picked up. These EMG signals may differ and may be used to achieve greater reliability and/or even more complex and detailed patterns of movements performed by a prosthesis such as an artificial limb.

Finally, as stated in claim 11, electroneurographic (ENG) signals may be received by one or more separate sets of ENG-electrodes and these ENG-signals may be used as complimentary signals for generating control signals. Hereby, further information concerning a desired movement may be provided and used to control a prosthesis. In cases where EMG signals may not be recorded, for example EMG signals stemming from muscles, which are absent, in particular the intrinsic muscles of the hand, it may be possible to record corresponding ENG signals, for example from the trunk nerves in the upper arm. These ENG signals will contain information complimentary to the EMG signals, whereby improved control of a prosthesis is provided. The ENG signals from the nerves may be provided in a number of ways known to a person skilled in the art.

The invention also relates to a system for controlling a prosthesis, such as an artificial limb, as claimed in claim 12. According to claim 12, electromyographic (EMG) signals are used to generate control signals for one or more artificial limbs and the system comprises one or more sets of dedicated electrodes, each placed in relation to a muscle, for receipt of the electromyographic (EMG) signals.

By using dedicated electrodes, i.e. electrodes designed and placed in such manner that the signals picked up by each of these electrodes emanate from a predefined source, e.g. a certain muscle or a certain compartment of a muscle, electromyographic (EMG) signals originating from well-defined sources may be picked up.

Consequently, EMG signals stemming from a muscle which would be activated by a human being when this human being would move a part of his body, e.g. a limb or a

part of a limb replaced by a prosthesis, may be detected, picked up and used to control the corresponding prosthesis or corresponding part of the prosthesis.

Thus, the system allows the user to move the prosthesis or part of the prosthesis in a highly intuitive way.

Further, by using the system, it will be possible to perform relatively complex movements of a prosthesis or part/parts thereof, as EMG signals may be received from muscles that would normally have been activated by the user of the prosthesis when performing the natural movements of missing body parts. These signals may thus be used to control the corresponding prosthesis parts, whereby the user may perform the desired movements intuitively, i.e. without having to learn to move particular muscle groups in a particular way and/or without having to activate switch-over mechanisms etc.

A further advantage of the system is related to environmental control, as the EMG control system may be applied for controlling light, appliances etc., which the user desires to control, e.g. turn on and off. Such an environmental control function may be incorporated in the EMG control system for controlling a prosthesis, whereby the user would be able to control such appliances, for example via wireless control, without actually having to manipulate a control means, e.g. a switch.

According to the preferred embodiment, as stated in claim 13, the one or more dedicated sets of electrodes of the system may be configured for subcutaneous, epimesial or intramuscular use, whereby it is ensured that relatively strong EMG signals from the corresponding muscle will be received by the electrode and that these signals will have a relatively high signal/noise ratio without interference from signals stemming from other sources, e.g. other muscles (cross talk).

Further, as stated in claim 14, said one or more sets of dedicated electrodes of the system may be configured for implantation in a muscle or muscles, whereby the

EMG signals will be received by the electrodes of the system in a relatively powerful form and without cross talk from other sources of EMG signals.

The muscles in which the sets of electrodes are implanted may for example be residual muscles related to a missing part of the body replaced by a prosthesis, e.g. muscles in an arm of a below elbow (BE) amputee. However, the sets of electrodes may be implanted in any residual limb or other muscles as desired in order to improve the EMG signal pattern discriminality. For example, a muscle in a shoulder part of an amputee may provide resourceful EMG signal information relating to the desired movements of for example a hand or an arm, whereby the functionality of the system may be enhanced.

As stated in claim 15, the system may comprise means for transmitting the electromyographic (EMG) signals from said one or more sets of dedicated electrodes to signal processing means by wireless transmission, whereby the disadvantages and/or discomfort associated with signal wires protruding through the skin of the user may be avoided.

According to a preferred embodiment of the system, and as stated in claim 16, the system comprises signal processing means for producing control signals for the artificial limb(s), said signal processing means utilizing a pattern recognition method. By this system, the control signals may be produced in an advantageous manner whereby the control signals may consistently lead to the desired movements of the prosthesis and/or part/parts thereof irrespective of the fact that the EMG signals may vary in form and/or amplitude.

As stated in claim 17, the system may comprise an artificial neural network (ANN) for generating control signals for the artificial limb(s), whereby the pattern recognition method may be performed by the system in a particularly advantageous manner.

Preferably, as stated in claim 18, the system may comprise four or more sets of dedicated electrodes placed in relation to at least four muscles, or combinations of func-

tional distinct muscle compartments, for receipt of electromyographic (EMG) signals. By this system, a sufficient number of distinct EMG signals may be provided in order to achieve at least four different movements of a limb or part/parts thereof.

As stated in claim 19, the system may be utilized to control an artificial arm and/or hand wherein one or more electrodes is/are placed in relation to at least the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus and Extensor Pollicis Longus. This system may provide at least four different movements of the artificial arm or part/parts thereof, for example closing and opening of a hand in a palmer grasp mode and closing and opening of a hand in a lateral grasp (also referred to as a key grip) mode.

As stated in claim 20, the system may be utilized to control an artificial arm and/or hand, wherein one or more electrodes is/are placed in relation to at least the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus, Extensor Pollicis Longus, Pronator Teres, Supinator, Flexor Carpi Radialis and Extensor Carpi Radialis. By this system, an artificial arm with an even larger degree of freedom may be controlled in a user-friendly and highly intuitive manner by the user. An artificial arm may for example be configured for opening/closing the hand and performing a palmer or a key grip, rotating or flexing the wrist, extending or flexing the fingers and the thumb (selectively) etc., making all these functions controllable by the amputee (the user) in a natural and highly intuitive manner.

The system may, as stated in claim 21, advantageously comprise two or more sets of dedicated electrodes placed in relation to at least one muscle, wherein said two or more dedicated electrodes are placed in relation to different parts of said at least one muscle. Hereby, EMG signals from different parts of the muscle may be picked up by the system. These EMG signals may differ and may be used by the system to achieve an even more complex and detailed pattern of movements performed by a prosthesis such as an artificial limb.

Finally, as stated in claim 22, the system may comprise one or more sets of electroneurographic (ENG) electrodes for receiving electroneurographic (ENG) signals which may be used as complimentary signals for generating control signals.

Hereby, further information concerning a desired movement may be provided and used to control a prosthesis. In cases where EMG signals may not be recorded, for example EMG signals stemming from muscles which are absent, in particular the intrinsic muscles of the hand, it may be possible to record corresponding ENG signals, for example from the trunk nerves in the upper arm. These ENG signals will contain information complimentary to the EMG signals when generating control signals, whereby an improved control system for a prosthesis is provided. The ENG electrodes for recording ENG signals from the nerves may be configured in a number of ways known to a person skilled in the art.

Figures

The invention will be described below with reference to the drawings of which

fig. 1 shows a cross section of the lower part of an arm illustrating the suggested positioning of dedicated electromyographic (EMG) electrodes according to the invention,

fig. 2 shows an example of an electromyographic (EMG) signal picked up by a sets of EMG electrodes according to the invention,

fig. 3 illustrates a system for recording, processing and evaluating EMG signals from a human being, and

fig. 4 illustrates a block diagram, wherein a pattern recognition circuit with artificial neural networks are utilized to control an artificial limb.

Detailed description

Fig. 1 illustrates a cross section of the right forearm of a human being, for example a human being who has lost a hand and perhaps part of the lower arm. The cross sec-

tion shown in fig. 1 thus illustrates the residual muscles in the remaining part of the lower arm.

The cross section might be an image of the arm provided by an MRI (magnetic resonance imaging) scanner, and the MRI technique may also be employed when implanting the electrodes according to the invention.

The view is from distal to proximal with the Dorsal surface at the top and with the Radial surface to the left of the figure. The figure indicates the relevant residual muscles for recording electromyographic (EMG) signals:

Flexor digitorum profundus 1,
Flexor digitorum superficialis 2,
Extensor digitorum 3,
Flexor pollicis longus 4,
Extensor pollicis longus 5,
Supinator 6,
Pronator teres 7,
Flexor carpi radials8,
Flexor carpi ulnaris 9,
Extensor carpi radialis brevis 10,
Extensor carpi radialis longus 11,
Extensor carpi ulnaris 12.

From the figure, it may be observed that several of these muscles are placed relatively deep in the arm and are not directly accessible. EMG signals from these muscles will thus be difficult to obtain with surface electrodes. In particular, Extensor pollicis longus 5, Supinator 6 and Flexor pollicis longus 4 are inaccessible and cannot be recorded by using surface mounted electrodes.

A selection of palmer grip versus key grip can be achieved by analyzing the EMG activity of four muscle groups:

Finger flexors: This can be Flexor digitorum profundus 1 or Flexor digitorum superficialis 2.
Finger extensors: This can be extensor digitorum 3.

Thumb flexor: This can be Flexor pollicis longus 4.
Thumb extensor: This can be Extensor pollicis longus 5.

A selection of the function of wrist movements (flexion; extension; pronation and supination) can be achieved by analyzing the EMG activity of four muscle groups:

Wrist supination: This can be Supinator 6.
Wrist pronation: This can be Pronator teres 7.

Wrist flexion: This can be Flexor carpi radials 8 or Flexor carpi ulnaris 9.
Wrist extension: This can be Extensor carpi radialis brevis 10, Extensor carpi radialis longus 11 or Extensor carpi ulnaris 12.

Electrodes for receiving electromyographic (EMG) signals from the muscles may be implanted in these muscles, for example in special parts of these muscles, where the signals may be picked up in a relatively strong form, with or without only a small amount of cross talk.

The electrodes may be monopolar, bipolar,tripolar etc. The electrodes may be placed percutaneously, whereby the signal wires will have to protrude through the skin of the user. This has some disadvantages such as the risk of infection and the discomfort to the user which makes the use of electrodes, which are totally implanted, preferable.

When totally implanted electrodes are used, the signals may be transmitted for example by telemetry by electromagnetic, optical or other means, to the surface of the arm and/or to the processing means of the signals.

Fig. 2 illustrates an example of a EMG signal picked up from a residual muscle in a lower arm. The signal from the EMG electrode has been processed, e.g. amplified (1000 – 10000), band-pass filtered (10 Hz – 1 kHz) and sampled (2 kHz). Further, the signal has been processed in order to remove DC-offset and motion artifacts (digital high pass, Butterworth order 4, 20 Hz). Finally, the signal has been full-wave rectified and a moving average signal has been provided (over a 25 ms sliding window) before the signal has been processed in order to determine an onset.

This has been done by applying a 200 ms sliding window 21 to the moving average signal. If the number of samples in this 200 ms window 21 exceeds an appropriate threshold value for at least 175 ms (not necessarily consecutively), the first point of this window 21 is labeled as the onset 22. Initial spikes 23 will thus not have any influence on the detection of the onset event 22.

Following the detection of an onset event, a search for an offset event, for example when the number of samples below the appropriate threshold exceeds 150 ms, takes place.

This is only an example of the signal processing to determine onset and offset. Other algorithms may be applied in connection with the invention.

Fig. 3 illustrates a system for recording, processing and evaluating EMG signals from a human being, for example in order to examine the signals from implanted electrodes, and for optimizing the positioning of electrodes, the signal processing means or the control means or in order to train a user of a system according to the invention.

A human being 30 who has lost a hand has had a number of EMG electrodes implanted in the forearm 31. These are connected by means of wires 32 to a signal processing means 33 comprising amplifiers and filters. The output from the processing means 33 is delivered to a data acquisition board and computer 34, where the

signals are stored and/or visualized. Further, the system comprises a computer 35 with a screen, on which an animation target 36 is shown.

The animation target 36 is a hand which may perform different movements, grips, etc., and the amputee 30 is asked to mimic with his phantom hand the animations performed by the hand 36. The signals may be stored by the computer 34, and the recorded signals corresponding to the movements and grips intended by the amputee may be used to configure a system according to the invention. In particular, the system illustrated in fig. 3 may be utilized for training artificial neural networks in order to configure a control system according to the invention and in order to individualize such a system.

Fig 4 illustrates a control system according to the invention wherein artificial neural networks (ANN) are utilized. A prosthesis 41 in the form of an artificial hand 41 is illustrated as the object to be controlled by the system. A number of EMG electrodes 43a – 43n are illustrated, each receiving EMG signals 42a – 42n, respectively. The output signals 44a - 44n are amplified, band-pass filtered and transmitted, for example by telemetry by electromagnetic, optical or other means, to a signal processing means 45, comprising for example additional amplifiers, filters etc. The output 46 from this processing means is led to a pattern recognition circuit 47 comprising for example artificial neural networks, wherein the signals are processed in order to determine which movements and/or grips are desired by the user.

From the pattern recognition circuit 47, a signal is sent to a control circuit 48 containing for example power and control circuits, and finally an output signal is led to the driving means 49 of the artificial hand 41.

In addition to the EMG electrodes 43a – 43n delivering signals 44a – 44n to the signal processing means 45, a number of ENG (electroneurographic) electrodes (not shown) may be utilized in connection with the system, providing additional information of the intended movements.

In this case, the invention has been described in relation to an artificial limb in the form of a hand. Evidently, the invention may be used in relation to prostheses in general, e.g. artificial arms, legs, feet, etc.

Further, the invention can be applied for environmental control in addition to control of prostheses. For example, a user may utilize the system to turn lights on and off, to open and close power-controlled doors, to control communication means, to control input to communication means, e.g. computers, to control vehicles, to control appliances etc.

Patent Claims

1. A method of controlling a prosthesis such as an artificial limb, whereby electromyographic (EMG) signals are used to generate control signals for one or more prostheses such as artificial limbs and whereby the electromyographic (EMG) signals are received by one or more sets of electrodes dedicated to a source of electromyographic (EMG) signals.

2. Method according to claim 1, characterized in that said one or more sets of dedicated electrodes is/are placed subcutaneously, epimesially or intramuscularly.

3. Method according to claim 1 or 2, characterized in that said one or more sets of dedicated electrodes are implanted in a muscle or muscles.

4. Method according to one or more of claims 1 - 3, characterized in that the electromyographic (EMG) signals from said one or more sets of dedicated electrodes are transmitted to signal processing means by wireless transmission.

5. Method according to one or more of claims 1 - 4, characterized in that the electromyographic (EMG) signals from said one or more sets of dedicated electrodes are processed by signal processing means, whereby control signals for the artificial limb(s) are produced, said signal processing means utilizing a pattern recognition method.

6. Method according to one or more of claims 1 - 5, characterized in that the control signals of the artificial limb(s) are generated by utilizing an artificial neural network (ANN).

7. Method according to one or more of claims 1 - 6, characterized in that the electromyographic (EMG) signals are received by four or more sets of

dedicated electrodes placed in relation to at least four muscles or distinct functional muscle compartments.

8. Method according to claim 7, characterized in that the method is utilized to control an artificial arm and/or hand and in that one or more sets of electrodes are placed in relation to at least the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus and Extensor Pollicis Longus.

9. Method according to claim 7, characterized in that the method is utilized to control an artificial arm and/or hand and in that one or more electrodes are placed in relation to at least the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus, Extensor Pollicis Longus, Pronator Teres, Supinator, Flexor Carpi Radialis and Extensor Carpi Radialis.

10. Method according to one or more of claims 1 - 9, characterized in that two or more sets of dedicated electrodes are placed in relation to at least one muscle, said two or more dedicated electrodes being placed in relation to different parts of said at least one muscle.

11. Method according to one or more of claims 1 - 10, characterized in that electroneurographic (ENG) signals are received by one or more separate sets of ENG-electrodes and that these ENG-signals are used as complimentary signals for generating control signals.

12. A system for controlling a prosthesis, such as an artificial limb, wherein electromyographic (EMG) signals are used to generate control signals for one or more artificial limbs and wherein the system comprises one or more sets of electrodes, each dedicated to a source of electromyographic (EMG) signals for receipt of the electromyographic (EMG) signals.

13. System according to claim 12, characterized in that said one or more sets of dedicated electrodes is/are configured for subcutaneous, epimesial or intramuscular placing.

14. System according to claim 12 or 13, characterized in that said one or more sets of dedicated electrodes is/are configured for an implantation in a muscle or muscles.

15. System according to one or more of claims 12 - 14, characterized in that the system comprises means for transmitting the electromyographic (EMG) signals from said one or more sets of dedicated electrodes to signal processing means by wireless transmission.

16. System according to one or more of claims 12 - 15, characterized in that the system comprises signal processing means for producing control signals for the artificial limb(s), said signal processing means utilizing a pattern recognition method.

17. System according to one or more of claims 12 - 16, characterized in that the system comprises an artificial neural network (ANN) for generating control signals for the artificial limb(s).

18. System according to one or more of claims 12 - 17, characterized in that the system comprises four or more sets of dedicated electrodes placed in relation to at least four muscles or functional distinct muscle compartments for receipt of electromyographic (EMG) signals.

19. System according to claim 18, characterized in that the system is utilized to control an artificial arm and/or hand wherein one or more sets of electrodes is/are placed in relation to at least the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus and Extensor Pollicis Longus.

20. System according to claim 18, characterized in that the system is utilized to control an artificial arm and/or hand and in that one or more sets of electrodes is/are placed in relation to at least the following muscles: Flexor Digitorum, Extensor Digitorum, Flexor Pollicis Longus, Extensor Pollicis Longus, Pronator Teres, Supinator, Flexor Carpi Radialis and Extensor Carpi Radialis.

21. System according to one or more of claims 12 - 20, characterized in that the system comprises two or more sets of dedicated electrodes placed in relation to at least one muscle, and in that said two or more sets of dedicated electrodes is/are placed in relation to different parts of said at least one muscle.

22. Method according to one or more of claims 12 - 21, characterized in that the system comprises one or more sets of electroneurographic (ENG) electrodes for receiving electroneurographic (ENG) signals and in that these ENG-signals are used as complimentary signals for generating control signals.

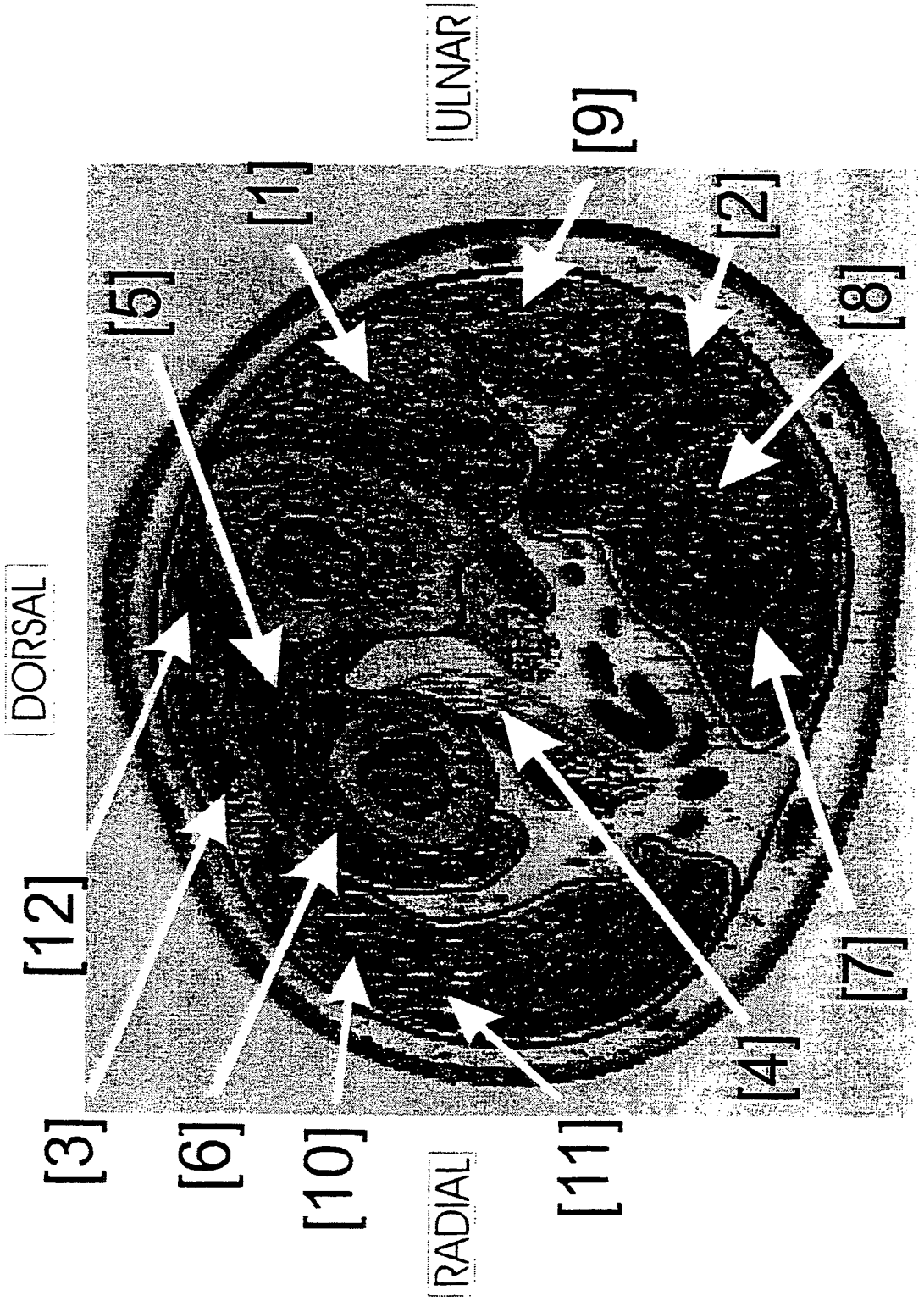
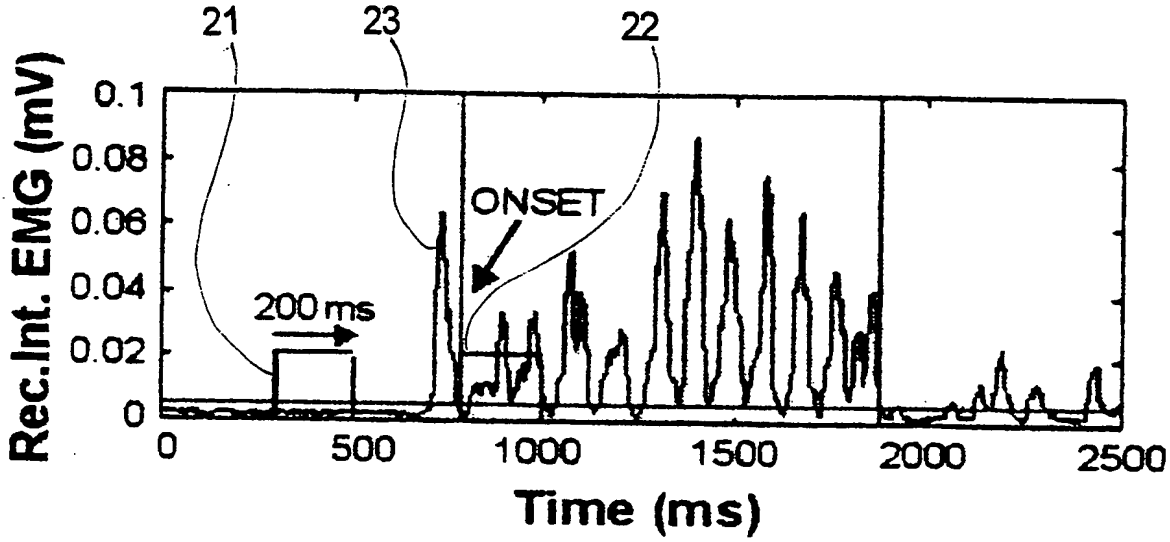


Fig. 1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23
22
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0.08
0.06
0.04
0.02
0
ONSET
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1000
1500
2000
2500
Time (ms)

Fig. 2

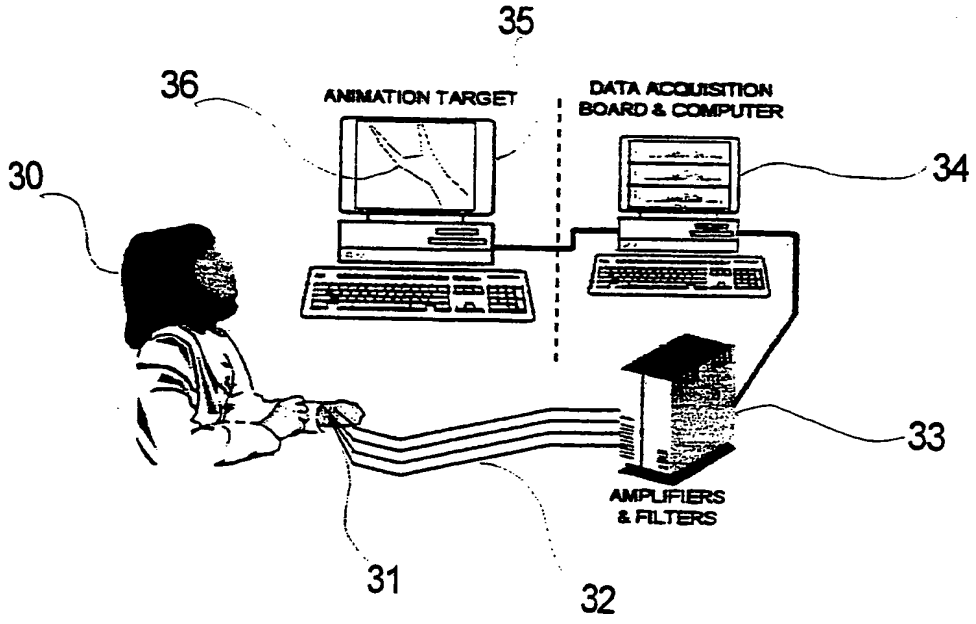
35
36
ANIMATION TARGET
DATA ACQUISITION
BOARD & COMPUTER
30
34
33
AMPLIFIERS
& FILTERS
31
32

Fig. 3

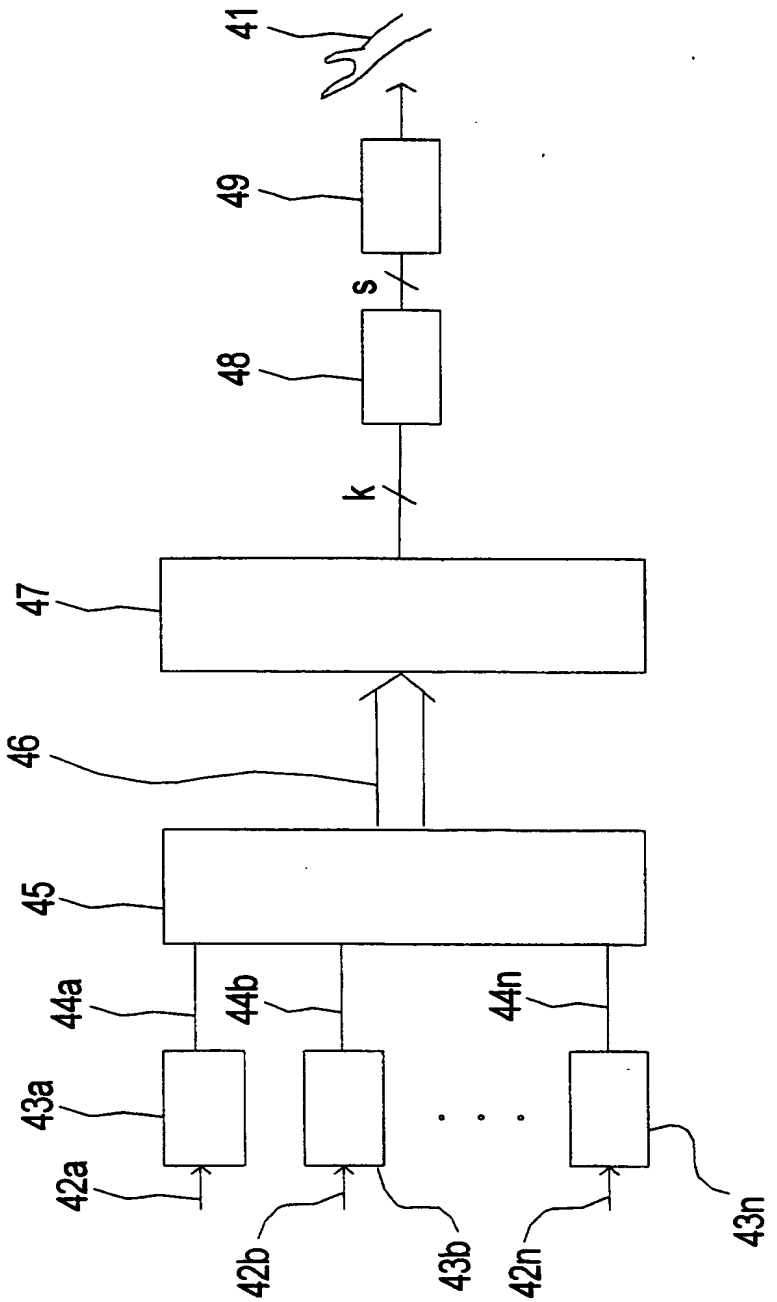

Fig. 4

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Published:
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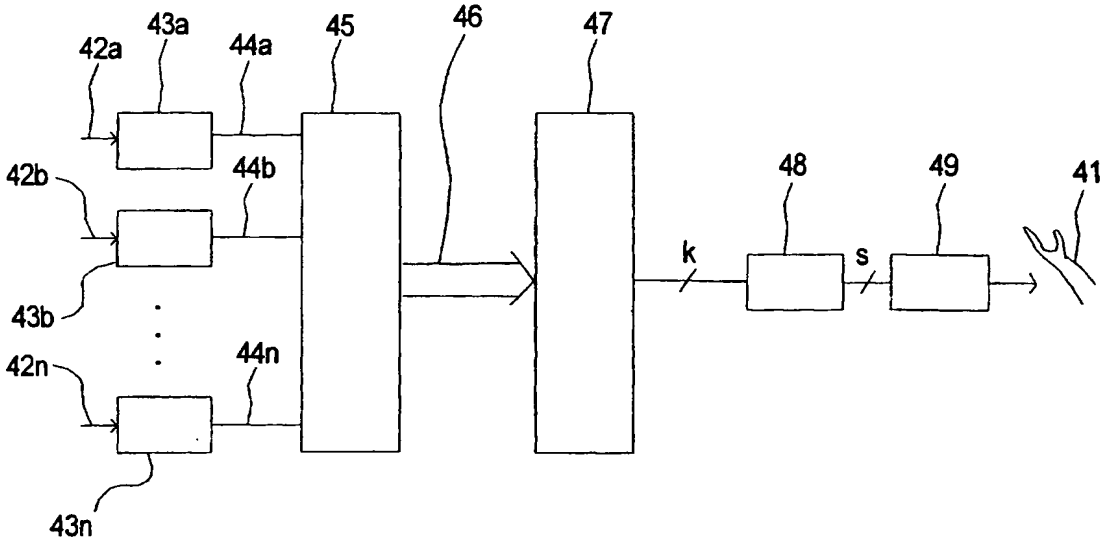
6 December 2001

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: EMG CONTROL OF PROSTHESIS



(57) Abstract: A method and a system for controlling a prosthesis such as an artificial limb. Electromyographic (EMG) signals are used to generate control signals for one or more prostheses such as artificial limbs. The electromyographic (EMG) signals are received by one or more sets of electrodes dedicated to a source of electromyographic (EMG) signals. By using dedicated electrodes, electromyographic (EMG) signals originating from well-defined sources may be picked up. Consequently, EMG signals stemming from a muscle which would be activated by a human being when this human being would move a part of his body, e.g. a limb or a part of a limb replaced by a prosthesis, may be detected, picked up and used to control the corresponding prosthesis or corresponding part of the prosthesis.

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INTERNATIONAL SEARCH REPORT

Intern ial Application No
PCT/DK 00/00464

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61F2/72

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MUNOZ R ET AL: "Implantable electrode for chronic recording from skeletal muscle" PROCEEDINGS - 19TH INTERNATIONAL CONFERENCE - IEEE/EMBS, 30 October 1997 (1997-10-30) - 2 November 1997 (1997-11-02), pages 2445-2447, XP002901486 CHICAGO, IL. US page 2445, column 1 ---	1-3, 7-10, 12-14, 18-21
X	EP 0 421 780 A (STEEPER HUGH LTD) 10 April 1991 (1991-04-10) column 1, line 1 -column 2, line 50 -----	1,5-12, 16-21

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 December 2000	21 05 2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Cilla Lyckman

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 00/00464

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-3,5-10,12-14,16-21

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-3,5-10,12-14,16-21

   The method according to claim 2-3 and 7-10 and corresponding system in claims 13,14 and 18-21 including the additional feature of the placement of the electrodes

2. Claims: 4,15

   The method and the system accrding to claims 4 and 15 including the additional feature that the EMG signals from the electrodes are transmitted to signal processing means by wireless transmission

3. Claims: 5,6,16,17

   The method according to claims 5 and 6 and the corresponding system in claims 16 and 17 including the additional feature that a pattern recognition method is used to produce the control signals for the prosthesis

4. Claims: 11,22

   The method and the system according to claims 11 and 22 including the additional feature that electroneurographic signals are used as complimentary signals for generating control signals

INTERNATIONAL SEARCH REPORT

information on patent family members

Intern ial Application No
PCT/DK 00/00464

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0421780 A	10-04-1991	DE 69029553 D	13-02-1997
		DE 69029553 T	12-06-1997